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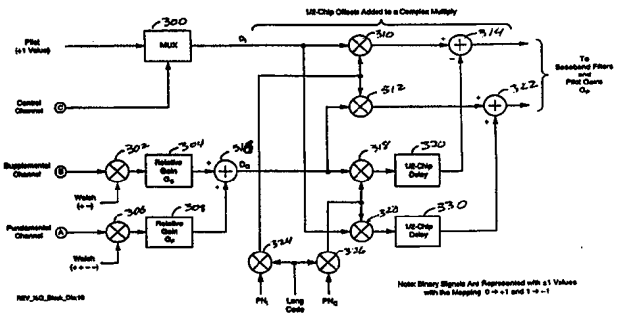

3G Reverse Link

(57) Abstract

A set of individually gain adjusted subscriber channels (A, B, C, Pilot) are formed via the use of a set of orthogonal subchannel codes (Walsh+–, Walsh++––) having a small number of PN spreading chips per orthogonal waveform period. Data to be transmitted via one of the transmit channels is low code rate error correction encoded and sequence repeated before being modulated with one of the subchannel codes, gain adjusted, and summed with data modulated using the other subchannel codes. The resulting summed data (316) is modulated using a user long code and a pseudorandom spreading code (PN code) and upconverted for transmission. The use of the short orthogonal codes provides interference suppression while still allowing extensive error correction coding and repetition for time diversity to overcome the Raleigh fading commonly experienced in terrestrial wireless systems. The set of sub–channel code may comprise four Walsh codes, each orthogonal to the remaining codes of the set. The use of four sub–channels is preferred as it allows shorter orthogonal codes to be used, however, the use of a greater number of channels and therefore longer codes is acceptable. Preferably, the pilot data and control data are combined onto one channel. The remaining two transmit channels are used for transmitting non–specified digital data including user data or signaling data, or both.

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A SUBSCRIBER UNIT AND METHOD FOR USE IN A WIRELESS COMMUNICATION SYSTEM

BACKGROUND OF THE INVENTION

I. Field of the Invention

The present invention relates to a subscriber unit and method for use in a wireless communication system.

II. Description of the Related Art

Wireless communication systems including cellular, satellite and point to point communication systems use a wireless link comprised of a modulated radio frequency (RF) signal to transmit data between two systems. The use of a wireless link is desirable for a variety of reasons including increased mobility and reduced infrastructure requirements when compared to wire line communication systems. One drawback of using a wireless link is the limited amount of communication capacity that results from the limited amount of available RF bandwidth. This limited communication capacity is in contrast to wire based communication systems where additional capacity can be added by installing additional wire line connections.

Recognizing the limited nature of RF bandwidth, various signal processing techniques have been developed for increasing the efficiency with which wireless communication systems utilize the available RF bandwidth. One widely accepted example of such a bandwidth efficient signal processing technique is the IS-95 over the air interface standard and its derivatives such as IS-95-A and ANSI J-STD-008 (referred to hereafter collectively as the IS-95 standard) promulgated by the telecommunication industry association (TIA) and used primarily within cellular telecommunications systems. The IS-95 standard incorporates code division multiple access (CDMA) signal modulation techniques to conduct multiple communications simultaneously over the same RF bandwidth. When combined with comprehensive power control, conducting multiple communications over the same bandwidth increases the total number of calls and other communications that can be conducted in a wireless communication system by, among other things, increasing the frequency reuse in comparison to other wireless telecommunication technologies. The use of CDMA techniques in a multiple access communication system is

disclosed in U.S. Patent No. 4,901,307, entitled "SPREAD SPECTRUM COMMUNICATION SYSTEM USING SATELLITE OR TERRESTRIAL REPEATERS", and U.S. Patent No. 5,103,459, entitled "SYSTEM AND METHOD FOR GENERATING SIGNAL WAVEFORMS IN A CDMA CELLULAR TELEPHONE SYSTEM", both of which are assigned to the assignee of the present invention and incorporated by reference herein.

Fig. 1 provides a highly simplified illustration of a cellular telephone system configured in accordance with the use of the IS-95 standard. During operation, a set of subscriber units **10a - d** conduct wireless communication by establishing one or more RF interfaces with one or more base stations **12a - d** using CDMA modulated RF signals. Each RF interface between a base station **12** and a subscriber unit **10** is comprised of a forward link signal transmitted from the base station **12**, and a reverse link signal transmitted from the subscriber unit. Using these RF interfaces, a communication with another user is generally conducted by way of mobile telephone switching office (MTSO) **14** and public switch telephone network (PSTN) **16**. The links between base stations **12**, MTSO **14** and PSTN **16** are usually formed via wire line connections, although the use of additional RF or microwave links is also known.

In accordance with the IS-95 standard each subscriber unit **10** transmits user data via a single channel, non-coherent, reverse link signal at a maximum data rate of 9.6 or 14.4 kbits/sec depending on which rate set from a set of rate sets is selected. A non-coherent link is one in which phase information is not utilized by the received system. A coherent link is one in which the receiver exploits knowledge of the carrier signals phase during processing. The phase information typically takes the form of a pilot signal, but can also be estimated from the data transmitted. The IS-95 standard calls for a set of sixty four Walsh codes, each comprised of sixty four chips, to be used for the forward link.

The use of a single channel, non-coherent, reverse link signal having a maximum data rate of 9.6 of 14.4 kbits/sec as specified by IS-95 is well suited for a wireless cellular telephone system in which the typical communication involves the transmission of digitized voice or lower rate digital data such a facsimile. A non-coherent reverse link was selected because, in a system in which up to 80 subscriber units **10** may communicate with a base station **12** for each 1.2288 MHz of bandwidth allocated, providing the necessary pilot data in the transmission from each subscriber unit **10** would substantially increase the degree to which a set of subscriber units **10**

interfere with one another. Also, at data rates of 9.6 or 14.4 kbits/sec, the ratio of the transmit power of any pilot data to the user data would be significant, and therefore also increase inter-subscriber unit interference. The use of a single channel reverse link signal was chosen because engaging in only one type of communication at a time is consistent with the use of wireline telephones, the paradigm on which current wireless cellular communications is based. Also, the complexity of processing a single channel is less than that associated with processing multiple channels.

As digital communications progress, the demand for wireless transmission of data for applications such as interactive file browsing and video teleconferencing is anticipated to increase substantially. This increase will transform the way in which wireless communications systems are used, and the conditions under which the associated RF interfaces are conducted. In particular, data will be transmitted at higher maximum rates and with a greater variety of possible rates. Also, more reliable transmission may become necessary as errors in the transmission of data are less tolerable than errors in the transmission of audio information. Additionally, the increased number of data types will create a need to transmit multiple types of data simultaneously. For example, it may be necessary to exchange a data file while maintaining an audio or video interface. Also, as the rate of transmission from a subscriber unit increases the number of subscriber units **10** communicating with a base station **12** per amount of RF bandwidth will decrease, as the higher data transmission rates will cause the data processing capacity of the base station to be reached with fewer subscriber units **10**. In some instances, the current IS-95 reverse link may not be ideally suited for all these changes. Therefore, the present invention is related to providing a higher data rate, bandwidth efficient, CDMA interface over which multiple types of communication can be performed.

SUMMARY OF THE INVENTION

In one aspect the invention provides a subscriber unit or other transmitter for use in a wireless communication system, the subscriber unit comprising: plural information sources of information data; an encoder for encoding the information data; plural control sources of control data; and a modulator for modulating encoded information data with respective different modulating codes for transmission on a carrier signal, for combining the control data from the plural sources, and outputting the encoded information data and the combined control data for transmission.

In another aspect the invention provides a base station or other receiver for use in a wireless communication system, the base station comprising: a receiver for receiving a carrier signal and removing therefrom encoded information data from plural information sources modulated with respective different modulating codes and control data from plural control sources with the encoded control data being combined with each other; a demodulator for demodulating the encoded information data and the control data from their respective different modulating codes; and a decoder for decoding the encoded information data and demodulating the control data.

In a further aspect the invention provides a method of transmission in a wireless communication system, the method comprising: acquiring plural information data; encoding the information data; acquiring plural control data; modulating encoded information data with respective different modulating codes for transmission on a carrier signal; combining the control data from the plural sources; and outputting the encoded information data and the combined control data for transmission.

In another aspect the invention provides a method for generating modulated data for transmission from a first subscriber unit in a set of subscriber units wherein said first subscriber unit transmits control data and pilot data to a base station in communication with the set of subscriber units comprising: a) combining said control data with said pilot data; and b)

modulating said combined control data and pilot data onto in accordance with a single channel modulation format.

In accordance with one embodiment of the invention, a set of individually gain adjusted subscriber channels are formed via the use of a set of orthogonal subchannel codes having a small number of PN spreading chips per orthogonal waveform period. Data to be transmitted via one of the transmit channels is low code rate error correction encoded and sequence repeated before being modulated with one of the subchannel codes, gain adjusted, and summed with data modulated using the other subchannel codes. The resulting summed data is modulated using a user long code and a pseudorandom spreading code (PN code) and upconverted for transmission. The use of the short orthogonal codes provides interference suppression while still allowing extensive error correction coding and repetition for time diversity to overcome the Raleigh fading commonly experienced in terrestrial wireless systems. In the exemplary embodiment of the invention provided, the set of sub-channel codes are

comprised of four Walsh codes, each orthogonal to the remaining set and four chips in duration.

In a preferred embodiment of the invention, two of the subscriber channel channels are multiplexed into a single traffic channel. The use of fewer traffic channels is preferred as it allows a smaller peak-to-average transmit power ratio. The use of different numbers of traffic channels is consistent with the invention.

In a first exemplary embodiment of the invention, pilot data is transmitted via a first one of the transmit channels and power control and other frame-by-frame control data are transmitted via a second transmit channel. In a preferred embodiment, the information on the pilot channel and the control subscriber channel, which includes the power control and frame-by-frame control data, are multiplex together onto one traffic channel to reduce the peak-to-average power ratio while still allowing for a continuous transmission. A continuous transmission is very desirably because it minimizes the possible interference with personal electronic equipment such as hearing aids and pacemakers. Since the pilot and control data are always transmitted, the resulting signal is still continuous. The other traffic channels are typically only active when the data of the type of that traffic channel is active. If the control data were multiplexed with a subscriber channel other than the pilot subscriber channel, the resulting traffic channel waveform would be discontinuous when the original traffic channel data is inactive. The other subscriber traffic channels could also be multiplexed into a single transmit channel. Two separate subscriber traffic channels are used here to allow for different gains and frame retransmission approaches for different types of traffic. The remaining two transmit channels are used for transmitting non-specified digital data including user data or signaling data, or both. In the exemplary embodiment, one of the two non-specified transmit channels is configured for BPSK modulation and the other for QPSK modulation. This is done to illustrate the versatility of the system. Both channels could be BPSK modulated or QPSK modulated in alternative embodiments of the invention.

Before modulation, the non-specified data is encoded where that encoding includes cyclic redundancy check (CRC) generation, convolutional encoding, interleaving, selective sequence repeating and BPSK or QPSK mapping. By varying the amount of repeating performed, and not restricting the amount of repeating to an integer number of symbol sequences, a wide variety of transmission rates including high data rates can

be achieved. Furthermore, higher data rates can also be achieved by transmitting data simultaneously over both non-specified transmit channels. Also, by frequently updating the gain adjust performed on each transmit channel, the total transmit power used by the transmit system may be kept to a minimum such that the interference generated between multiple transmit systems is minimized, thereby increasing the overall system capacity.

BRIEF DESCRIPTION OF THE DRAWINGS

The features, objects, and advantages of the present invention will become more apparent from the detailed description set forth below of an embodiment of the invention when taken in conjunction with the drawings in which like reference characters identify correspondingly throughout and wherein:

Fig. 1 is a block diagram of cellular telephone system;

Fig. 2 is a block diagram of a subscriber unit and base station configured in accordance with an exemplary embodiment of the invention;

Fig. 3 is a block diagram of a BPSK channel encoder and a QPSK channel encoder configured in accordance with the exemplary embodiment of the invention;

Fig. 4 is a block diagram of a transmit signal processing system configured in accordance with the exemplary embodiment of the invention;

Fig. 5 is a block diagram of a receive processing system configured in accordance with the exemplary embodiment of the invention;

Fig. 6 is a block diagram of a finger processing system configured in accordance with one embodiment of the invention;

Fig. 7 is a block diagram of a BPSK channel decoder and a QPSK channel decoder configured in accordance with the exemplary embodiment of the invention; and

Fig. 8 is a block diagram of the transmission system embodying the present invention wherein the control data and pilot data have been combined onto one channel;

Fig. 9 is a block diagram of the transmission system embodying the present invention wherein the control data and pilot data have been combined onto one channel including the filtering of the signals to be transmitted;

Fig. 10 is a receiver system embodying the present invention for receiving data wherein the power data and pilot data have been combined onto one channel.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

A novel and improved method and apparatus for high rate CDMA wireless communication is described in the context of the reverse link transmission portion of a cellular telecommunications system. While the invention may be adapted for use within the multipoint-to-point reverse link transmission of a cellular telephone system, the present invention is equally applicable to forward link transmissions. In addition, many other wireless communication systems will benefit by incorporation of the invention, including satellite based wireless communication systems, point to point wireless communication systems, and systems transmitting radio frequency signals via the use of co-axial or other broadband cables.

Fig. 2 is a block diagram of receive and transmit systems configured as a subscriber unit **100** and a base station **120** in accordance with one embodiment of the invention. A first set of data (BPSK data) is received by BPSK channel encoder **103,** which generates a code symbol stream configured for performing BPSK modulation that is received by modulator **104**. A second set of data (QPSK data) is received by QPSK channel encoder **102,** which generates a code symbol stream configured for performing QPSK modulation that is also received by modulator **104**. Modulator **104** also receives power control data and pilot data, which are modulated along with the BPSK and QPSK encoded data in accordance with code division multiple access (CDMA) techniques to generate a set of modulation symbols received by RF processing system **106**. RF processing system **106** filters and upconverts the set of modulation symbols to a carrier frequency for transmission to the base station **120** using antenna **108**. While only one subscriber unit **100** is shown, multiple subscriber units may communicate with base station **120**.

Within base station **120,** RF processing system **122** receives the transmitted RF signals by way of antenna **121** and performs bandpass filtering, downconversion to baseband, and digitization. Demodulator **124** receives the digitized signals and performs demodulation in accordance with CDMA techniques to produce power control, BPSK, and QPSK soft decision data. BPSK channel decoder **128** decodes the BPSK soft decision

data received from demodulator **124** to yield a best estimate of the BPSK data, and QPSK channel decoder **126** decodes the QPSK soft decision data received by demodulator **124** to produce a best estimate of the QPSK data. The best estimate of first and second set of data is then available for further processing or forwarding to a next destination, and the received power control data used either directly, or after decoding, to adjust the transmit power of the forward link channel used to transmit data to subscriber unit **100**.

Fig. 3 is a block diagram of BPSK channel encoder **103** and QPSK channel encoder **102** when configured in accordance with the exemplary embodiment of the invention. Within BPSK channel encoder **103** the BPSK data is received by CRC check sum generator **130** which generates a check sum for each 20 ms frame of the first set of data. The frame of data along with the CRC check sum is received by tail bit generator **132** which appends tail bits comprised of eight logic zeros at the end of each frame to provide a known state at the end of the decoding process. The frame including the code tail bits and CRC check sum is then received by convolutional encoder **134** which performs, constraint length (K) 9, rate (R) 1/4 convolutional encoding thereby generating code symbols at a rate four times the encoder input rate (E_R). In an alternative, other encoding rates are performed including rate 1/2, but the use of rate 1/4 is preferred due to its optimal complexity-performance characteristics. Block interleaver **136** performs bit interleaving on the code symbols to provide time diversity for more reliable transmission in fast fading environments. The resulting interleaved symbols are received by variable starting point repeater **138**, which repeats the interleaved symbol sequence a sufficient number of times N_R to provide a constant rate symbol stream, which corresponds to outputting frames having a constant number of symbols. Repeating the symbol sequence also increases the time diversity of the data to overcome fading. In the exemplary embodiment, the constant number of symbols is equal to 6,144 symbols for each frame making the symbol rate 307.2 kilosymbols per second (ksps). Also, repeater **138** uses a different starting point to begin the repetition for each symbol sequence. When the value of N_R necessary to generate 6,144 symbols per frame is not an integer, the final repetition is only performed for a portion of the symbol sequence. The resulting set of repeated symbols are received by BPSK mapper **139** which generates a BPSK code symbol stream (BPSK) of +1 and -1 values for performing BPSK modulation. In an alternative embodiment of the invention repeater **138** is

placed before block interleaver **136** so that block interleaver **136** receives the same number of symbols for each frame.

Within QPSK channel encoder **102** the QPSK data is received by CRC check sum generator **140** which generates a check sum for each 20 ms frame. The frame including the CRC check sum is received by code tail bits generator **142** which appends a set of eight tail bits of logic zeros at the end of the frame. The frame, now including the code tail bits and CRC check sum, is received by convolutional encoder **144** which performs K=9, R=1/4 convolutional encoding thereby generating symbols at a rate four times the encoder input rate (E_R). Block interleaver **146** performs bit interleaving on the symbols and the resulting interleaved symbols are received by variable starting point repeater **148**. Variable starting point repeater **148** repeats the interleaved symbol sequence a sufficient number of times N_R using a different starting point within the symbol sequence for each repetition to generate 12,288 symbols for each frame making the code symbol rate 614.4 kilosymbols per second (ksps). When N_R is not an integer, the final repetition is performed for only a portion of the symbol sequence. The resulting repeated symbols are received by QPSK mapper **149** which generates a QPSK code symbol stream configured for performing QPSK modulation comprised of an in-phase QPSK code symbol stream of +1 and -1 values ($QPSK_I$), and a quadrature-phase QPSK code symbol stream of +1 and -1 values ($QPSK_Q$). In an alternative embodiment of the invention repeater **148** is placed before block interleaver **146** so that block interleaver **146** receives the same number of symbols for each frame.

Fig. 4 is a block diagram of modulator **104** of **Fig. 2** configured in accordance with the exemplary embodiment of the invention. The BPSK symbols from BPSK channel encoder **103** are each modulated by Walsh code W_2 using a multiplier **150b**, and the $QPSK_I$ and $QPSK_Q$ symbols from QPSK channel encoder **102** are each modulated with Walsh code W_3 using multipliers **150c** and **154d**. The power control data (PC) is modulated by Walsh code W_1 using multiplier **150a**. Gain adjust **152** receives pilot data (PILOT), which in the preferred embodiment of the invention is comprised of the logic level associated with positive voltage, and adjusts the amplitude according to a gain adjust factor A_0. The PILOT signal provides no user data but rather provides phase and amplitude information to the base station so that it can coherently demodulate the data carried on the remaining sub-channels, and scale the soft-decision output values for combining. Gain adjust **154** adjusts the amplitude of the Walsh code W_1 modulated power

control data according to gain adjust factor A_1, and gain adjust **156** adjusts the amplitude of the Walsh code W_2 modulated BPSK channel data according amplification variable A_2. Gain adjusts **158a** and **b** adjust the amplitude of the in-phase and quadrature-phase Walsh code W_3 modulated QPSK symbols respectively according to gain adjust factor A_3. The four Walsh codes used in the preferred embodiment of the invention are shown in Table I.

Walsh Code	Modulation Symbols
W_0	+ + + +
W_1	+ - + -
W_2	+ + - -
W_3	+ - - +

Table I.

It will be apparent to one skilled in the art that the W_0 code is effectively no modulation at all, which is consistent with processing of the pilot data shown. The power control data is modulated with the W_1 code, the BPSK data with the W_2 code, and the QPSK data with the W_3 code. Once modulated with the appropriate Walsh code, the pilot, power control data, and BPSK data are transmitted in accordance with BPSK techniques, and the QPSK data ($QPSK_I$ and $QPSK_Q$) in accordance with QPSK techniques as described below. It should also be understood that it is not necessary that every orthogonal channel be used, and that the use of only three of the four Walsh codes where only one user channel is provided is employed in an alternative embodiment of the invention.

The use of short orthogonal codes generates fewer chips per symbol, and therefore allows for more extensive coding and repetition when compared to systems incorporating the use of longer Walsh codes. This more extensive coding and repetition provides protection against Raleigh fading which is a major source of error in terrestrial communication systems. The use of other numbers of codes and code lengths is consistent with the present invention, however, the use of a larger set of longer Walsh codes reduces this enhanced protection against fading. The use of four chip codes is considered optimal because four channels provides substantial

flexibility for the transmission of various types of data as illustrated below while also maintaining short code length.

Summer **160** sums the resulting amplitude adjusted modulation symbols from gain adjusts **152, 154, 156** and **158a** to generate summed modulation symbols **161.** PN spreading codes PN_I and PN_Q are spread via multiplication with long code **180** using multipliers **162a** and **b.** The resulting pseudorandom code provided by multipliers **162a** and **162b** are used to modulate the summed modulation symbols **161,** and gain adjusted quadrature-phase symbols $QPSK_Q$ **163,** via complex multiplication using multipliers **164a-d** and summers **166a** and **b.** The resulting in-phase term X_I and quadrature-phase term X_Q are then filtered (filtering not shown), and upconverted to the carrier frequency within RF processing system **106** shown in a highly simplified form using multipliers **168** and an in-phase and a quadrature-phase sinusoid. An offset QPSK upconversion could also be used in an alternative embodiment of the invention. The resulting in-phase and quadrature-phase upconverted signals are summed using summer **170** and amplified by master amplifier **172** according to master gain adjust A_M to generate signal s(t) which is transmitted to base station **120.** In the preferred embodiment of the invention, the signal is spread and filtered to a 1.2288 MHz bandwidth to remain compatible with the bandwidth of existing CDMA channels.

By providing multiple orthogonal channels over which data may be transmitted, as well as by using variable rate repeaters that reduce the amount of repeating N_R performed in response to high input data rates, the above described method and system of transmit signal processing allows a single subscriber unit or other transmit system to transmit data at a variety of data rates. In particular, by decreasing the rate of repetition N_R performed by variable starting point repeaters **138** or **148** of **FIG. 3,** an increasingly higher encoder input rate E_R can be sustained. In an alternative embodiment of the invention rate 1/2 convolution encoding is performed with the rate of repetition N_R increased by two. A set of exemplary encoder rates E_R supported by various rates of repetition N_R and encoding rates R equal to 1/4 and 1/2 for the BPSK channel and the QPSK channel are shown in Tables II and III respectively.

Label	$E_{R,BPSK}$ (bps)	Encoder Out R=1/4 (bits/frame)	$N_{R,R=1/4}$ (Repetition Rate, R=1/4)	Encoder Out R=1/2 (bits/frame)	$N_{R,R=1/2}$ (Repetition Rate, R=1/2)
High Rate-72	76,800	6,144	1	3,072	2
High Rate-64	70,400	5,632	1 1/11	2,816	2 2/11
	51,200	4,096	1 1/2	2,048	3
High Rate-32	38,400	3,072	2	1,536	4
	25,600	2,048	3	1,024	6
RS2-Full Rate	14,400	1,152	5 1/3	576	10 2/3
RS1-Full Rate	9,600	768	8	384	16
NULL	850	68	90 6/17	34	180 12/17

Table II. BPSK Channel

Label	$E_{R,QPSK}$ (bps)	Encoder Out R=1/4 (bits/frame)	$N_{R,R=1/4}$ (Repetition Rate, R=1/4)	Encoder Out R=1/2 (bits/frame)	$N_{R,R=1/2}$ (Repetition Rate, R=1/2)
	153,600	12,288	1	6,144	2
High Rate-72	76,800	6,144	2	3,072	4
High Rate-64	70,400	5,632	2 2/11	2,816	4 4/11
	51,200	4,096	3	2,048	6
High Rate-32	38,400	3,072	4	1,536	8
	25,600	2,048	6	1,024	12
RS2-Full Rate	14,400	1,152	10 2/3	576	21 1/3
RS1-Full Rate	9,600	768	16	384	32
NULL	850	68	180 12/17	34	361 7/17

Table III. QPSK Channel

Tables II and III show that by adjusting the number of sequence repetitions N_R, a wide variety of data rates can be supported including high data rates, as the encoder input rate E_R corresponds to the data transmission rate minus a constant necessary for the transmission of CRC, code tail bits and any other overhead information. As also shown by tables II and III, QPSK modulation may also be used to increase the data transmission rate. Rates expected to be used commonly are provided labels such as "High Rate-

72" and "High Rate-32." Those rates noted as High Rate-72, High Rate-64, and High Rate-32 have traffic rates of 72, 64 and 32 kbps respectively, plus multiplexed in signaling and other control data with rates of 3.6, 5.2, and 5.2 kbps respectively, in the exemplary embodiment of the invention. Rates RS1-Full Rate and RS2-Full Rate correspond to rates used in IS-95 compliant communication systems, and therefore are also expected to receive substantial use for purposes of compatibility. The null rate is the transmission of a single bit and is used to indicate a frame erasure, which is also part of the IS-95 standard.

The data transmission rate may also be increased by simultaneously transmitting data over two or more of the multiple orthogonal channels performed either in addition to, or instead of, increasing the transmission rate via reduction of the repetition rate N_R. For example, a multiplexer (not shown) could split a single data source into a multiple data sources to be transmitted over multiple data sub-channels. Thus, the total transmit rate can be increased via either transmission over a particular channel at higher rates, or multiple transmission performed simultaneously over multiple channels, or both, until the signal processing capability of the receive system is exceeded and the error rate becomes unacceptable, or the maximum transmit power of the of the transmit system power is reached.

Providing multiple channels also enhances flexibility in the transmission of different types of data. For example, the BPSK channel may be designated for voice information and the QPSK channel designated for transmission of digital data. This embodiment could be more generalized by designating one channel for transmission of time sensitive data such as voice at a lower data rate, and designating the other channel for transmission of less time sensitive data such as digital files. In this embodiment interleaving could be performed in larger blocks for the less time sensitive data to further increase time diversity. In another embodiment of the invention, the BPSK channel performs the primary transmission of data, and the QPSK channel performs overflow transmission. The use of orthogonal Walsh codes eliminates or substantially reduces any interference among the set of channels transmitted from a subscriber unit, and thus minimizes the transmit energy necessary for their successful reception at the base station.

To increase the processing capability at the receive system, and therefore increase the extent to which the higher transmission capability of the subscriber unit may be utilized, pilot data is also transmitted via one of

the orthogonal channels. Using the pilot data, coherent processing can be performed at the receive system by determining and removing the phase offset of the reverse link signal. Also, the pilot data can be used to optimally weigh multipath signals received with different time delays before being combined in a rake receiver. Once the phase offset is removed, and the multipath signals properly weighted, the multipath signals can be combined decreasing the power at which the reverse link signal must be received for proper processing. This decrease in the required receive power allows greater transmissions rates to be processed successfully, or conversely, the interference between a set of reverse link signals to be decreased. While some additional transmit power is necessary for the transmission of the pilot signal, in the context of higher transmission rates the ratio of pilot channel power to the total reverse link signal power is substantially lower than that associated with lower data rate digital voice data transmission cellular systems. Thus, within a high data rate CDMA system the E_b/N_0 gains achieved by the use of a coherent reverse link outweigh the additional power necessary to transmit pilot data from each subscriber unit.

The use of gain adjusts **152** - **158** as well as master amplifier **172** further increases the degree to which the high transmission capability of the above described system can be utilized by allowing the transmit system to adapt to various radio channel conditions, transmission rates, and data types. In particular, the transmit power of a channel that is necessary for proper reception may change over time, and with changing conditions, in a manner that is independent of the other orthogonal channels. For example, during the initial acquisition of the reverse link signal the power of the pilot channel may need to be increased to facilitate detection and synchronization at the base station. Once the reverse link signal is acquired, however, the necessary transmit power of the pilot channel would substantially decrease, and would vary depending on various factors including the subscriber units rate of movement. Accordingly, the value of the gain adjust factor A_0 would be increased during signal acquisition, and then reduced during an ongoing communication. In another example, when information more tolerable of error is being transmitted via the forward link, or the environment in which the forward link transmission is taking place is not prone to fade conditions, the gain adjust factor A_1 may be reduced as the need to transmit power control data with a low error rate decreases. In one embodiment of the invention, whenever power control adjustment is not necessary the gain adjust factor A_1 is reduced to zero.

In another embodiment of the invention, the ability to gain adjust each orthogonal channel or the entire reverse link signal is further exploited by allowing the base station **120** or other receive system to alter the gain adjust of a channel, or of the entire reverse link signal, via the use of power control commands transmitted via the forward link signal. In particular, the base station may transmit power control information requesting the transmit power of a particular channel or the entire reverse link signal be adjusted. This is advantageous in many instances including when two types of data having different sensitivity to error, such as digitized voice and digital data, are being transmitted via the BPSK and QPSK channels. In this case, the base station **120** would establish different target error rates for the two associated channels. If the actual error rate of a channel exceeded the target error rate, the base station would instruct the subscriber unit to reduce the gain adjust of that channel until the actual error rate reached the target error rate. This would eventually lead to the gain adjust factor of one channel being increased relative to the other. That is, the gain adjust factor associated with the more error sensitive data would be increased relative to the gain adjust factor associated with the less sensitive data. In other instances, the transmit power of the entire reverse link may require adjustment due to fade conditions or movement of the subscriber unit **100**. In these instances, the base station **120** can do so via transmission of a single power control command.

Thus, by allowing the gain of the four orthogonal channels to be adjusted independently, as well as in conjunction with one another, the total transmit power of the reverse link signal can be kept at the minimum necessary for successful transmission of each data type, whether it is pilot data, power control data, signaling data, or different types of user data. Furthermore, successful transmission can be defined differently for each data type. Transmitting with the minimum amount of power necessary allows the greatest amount of data to be transmitted to the base station given the finite transmit power capability of a subscriber unit, and also reduces the interfere between subscriber units. This reduction in interference increases the total communication capacity of the entire CDMA wireless cellular system.

The power control channel used in the reverse link signal allows the subscriber unit to transmit power control information to the base station at a variety of rates including a rate of 800 power control bits per second. In the preferred embodiment of the invention, a power control bit instructs the

base station to increase or decrease the transmit power of the forward link traffic channel being used to transmit information to the subscriber unit. While it is generally useful to have rapid power control within a CDMA system, it is especially useful in the context of higher data rate communications involving data transmission, because digital data is more sensitive to errors, and the high transmission causes substantial amounts of data to be lost during even brief fade conditions. Given that a high speed reverse link transmission is likely to be accompanied by a high speed forward link transmission, providing for the rapid transmission of power control over the reverse link further facilitates high speed communications within CDMA wireless telecommunications systems.

In an alternative exemplary embodiment of the invention a set of encoder input rates E_R defined by the particular N_R are used to transmit a particular type of data. That is, data may be transmitted at a maximum encoder input rate E_R or at a set of lower encoder input rates E_R, with the associated N_R adjusted accordingly. In the preferred implementation of this embodiment, the maximum rates corresponds to the maximum rates used in IS-95 compliant wireless communication system, referred to above with respect to Tables II and III as RS1-Full Rate and RS2-Full Rate, and each lower rate is approximately one half the next higher rate, creating a set of rates comprised of a full rate, a half rate, a quarter rate, and an eighth rate. The lower data rates are preferable generated by increasing the symbol repetition rate N_R with value of N_R for rate set one and rate set two in a BPSK channel provided in Table IV.

Label	$E_{R,QPSK}$ (bps)	Encoder Out R=1/4 (bits/frame)	$N_{R,R=1/4}$ (Repetition Rate, R=1/4)	Encoder Out R=1/2 (bits/frame)	$N_{R,R=1/2}$ (Repetition Rate, R=1/2)
RS2-Full Rate	14,400	1,152	5 1/3	576	10 2/3
RS2-Half Rate	7,200	576	10 2/3	288	21 1/3
RS2-Quarter Rate	3,600	288	21 1/3	144	42 2/3
RS2-Eighth Rate	1,900	152	40 8/19	76	80 16/19
RS1-Full Rate	9,600	768	8	384	16
RS1-Half Rate	4,800	384	16	192	32
RS1-Quarter Rate	2,800	224	27 3/7	112	54 6/7
RS1-Eighth Rate	1,600	128	48	64	96
NULL	850	68	90 6/17	34	180 12/17

Table IV. RS1 and RS2 Rate Sets in BPSK Channel

The repetition rates for a QPSK channel is twice that for the BPSK channel.

In accordance with the exemplary embodiment of the invention, when the data rate of a frame changes with respect to the previous frame the transmit power of the frame is adjusted according to the change in transmission rate. That is, when a lower rate frame is transmitted after a higher rate frame, the transmit power of the transmit channel over which the frame is being transmitted is reduced for the lower rate frame in proportion to the reduction in rate, and vice versa. For example, if the transmit power of a channel during the transmission of a full rate frame is transmit power T, the transmit power during the subsequent transmission of a half rate frame is transmit power T/2. The reduction is transmit power is preferably performed by reducing the transmit power for the entire duration of the frame, but may also be performed by reducing the transmit duty cycle such that some redundant information is "blanked out." In either case, the transmit power adjustment takes place in combination with a closed loop power control mechanism whereby the transmit power is further adjusted in response to power control data transmitted from the base station.

Fig. 5 is a block diagram of RF processing system **122** and demodulator **124** of **Fig. 2** configured in accordance with the exemplary embodiment of

the invention. Multipliers **180a** and **180b** dowconvert the signals received from antenna **121** with an in-phase sinusoid and a quadrature phase sinusoid producing in-phase receive samples R_I and quadrature-phase receive samples R_Q receptively. It should be understood that RF processing system **122** is shown in a highly simplified form, and that the signals are also match filtered and digitized (not shown) in accordance with widely known techniques. Receive samples R_I and R_Q are then applied to finger demodulators **182** within demodulator **124**. Each finger demodulator **182** processes an instance of the reverse link signal transmitted by subscriber unit **100**, if such an instance is available, where each instance of the reverse link signal is generated via multipath phenomenon. While three finger demodulators are shown, the use of alternative numbers of finger processors are consistent with the invention including the use of a single finger demodulator **182**. Each finger demodulator **182** produces a set of soft decision data comprised of power control data, BPSK data, and $QPSK_I$ data and $QPSK_Q$ data. Each set of soft decision data is also time adjusted within the corresponding finger demodulator **182**, although time adjustment could be performed within combiner **184** in an alternative embodiment of the invention. Combiner **184** then sums the sets of soft decision data received from finger demodulators **182** to yield a single instance of power control, BPSK, $QPSK_I$ and $QPSK_Q$ soft decision data.

Fig. 6 is block diagram a finger demodulator **182** of **Fig. 5** configured in accordance with the exemplary embodiment of the invention. The R_I and R_Q receive samples are first time adjusted using time adjust **190** in accordance with the amount of delay introduced by the transmission path of the particular instance of the reverse link signal being processed. Long code **200** is mixed with pseudorandom spreading codes PN_I and PN_Q using multipliers **201**, and the complex conjugate of the resulting long code modulated PN_I and PN_Q spreading codes are complex multiplied with the time adjusted R_I and R_Q receive samples using multipliers **202** and summers **204** yielding terms X_I and X_Q. Three separate instances of the X_I and X_Q terms are then demodulated using the Walsh codes W_1, W_2 and W_3 respectively, and the resulting Walsh demodulated data is summed over four demodulation chips using 4 to 1 summers **212**. A fourth instance of the X_I and X_Q data is summed over four demodulation chips using summers **208**, and then filtered using pilot filters **214**. In the preferred embodiment of the invention pilot filter **214** performs averaging over a series of summations performed by summers **208**, but other filtering

techniques will be apparent to one skilled in the art. The filtered in-phase and quadrature-phase pilot signals are used to phase rotate and scale the W_1, and W_2 Walsh code demodulated data in accordance with BPSK modulated data via complex conjugate multiplication using multipliers **216** and adders **217** yielding soft decision power control and BPSK data. The W_3 Walsh code modulated data is phase rotated using the in-phase and quadrature-phase filtered pilot signals in accordance with QPSK modulated data using multipliers **218** and adders **220**, yielding soft decision QPSK data. The soft decision power control data is summed over 384 modulation symbols by 384 to 1 summer **222** yielding power control soft decision data. The phase rotated W_2 Walsh code modulated data, the W_3 Walsh code modulated data, and the power control soft decision data are then made available for combining. In an alternative embodiment of the invention, encoding and decoding is performed on the power control data as well.

In addition to providing phase information the pilot may also be used within the receive system to facilitate time tracking. Time tracking is performed by also processing the received data at one sample time before (early), and one sample time after (late), the present receive sample being processed. To determine the time that most closely matches the actual arrival time, the amplitude of the pilot channel at the early and late sample time can be compared with the amplitude at the present sample time to determine that which is greatest. If the signal at one of the adjacent sample times is greater than that at the present sample time, the timing can be adjusted so that the best demodulation results are obtained.

FIG. 7 is a block diagram of BPSK channel decoder **128** and QPSK channel decoder **126** (**Fig. 2**) configured in accordance with the exemplary embodiment of the invention. BPSK soft decision data from combiner **184** (**Fig. 5**) is received by accumulator **240** which stores the first sequence of $6{,}144/N_R$ demodulation symbols in the received frame where N_R depends on the transmission rate of the BPSK soft decision data as described above, and adds each subsequent set of $6{,}144/N_R$ demodulated symbols contained in the frame with the corresponding stored accumulated symbols. Block deinterleaver **242** deinterleaves the accumulated soft decision data from variable starting point summer **240**, and Viterbi decoder **244** decodes the deinterleaved soft decision data to produce hard decision data as well as CRC check sum results. Within QPSK decoder **126** $QPSK_I$ and $QPSK_Q$ soft decision data from combiner **184** (**Fig. 5**) are demultiplexed into a single soft decision data stream by demux **246** and the single soft decision data stream is

received by accumulator **248** which accumulates every $6,144/N_R$ demodulation symbols where N_R depends on the transmission rate of the QPSK data. Block deinterleaver **250** deinterleaves the soft decision data from variable starting point summer **248**, and Viterbi decoder **252** decodes the deinterleaved modulation symbols to produce hard decision data as well as CRC check sum results. In the alternative exemplary embodiment described above with respect to **Fig. 3** in which symbol repetition is performed before interleaving, accumulators **240** and **248** are placed after block deinterleavers **242** and **250**. In the embodiment of the invention incorporating the use of rate sets, and therefore in which the rate of particular frame is not known, multiple decoders are employed, each operating at a different transmission rate, and then the frame associated with the transmission rate most likely to have been used is selected based on the CRC checksum results. The use of other error checking methods is consistent with the practice of the present invention.

Now turning to FIG. 8, a reverse link transmission system in which the control data and the pilot data have been combined onto one channel is illustrated. It should be noted that the invention can be equally applied to forward link transmissions but offers additional advantages when provided in the remote mobile station. In addition, it will be understood by one skilled in the art that the control data can be multiplexed onto other channels transmitted by the remote station. However, in the preferred embodiment, the control data is multiplexed onto the pilot channel because unlike the fundamental and supplemental channels, the pilot channel is always present regardless of whether the remote station has traffic data to send to the central communications station. In addition, although the present invention is described in terms of multiplexing the data onto the pilot channel, it is equally applicable to the case where the power control data is punctured into the pilot channel.

Pilot data which consists solely of a stream of binary "1" values are provided to multiplexer (MUX) **300**. In addition the control channel data, which in the exemplary embodiment is power control data consisting of +1 and -1 values indicative of instruction for the base station to increase or decrease its transmission power, are provided to MUX **300**. Multiplexer **300** combines the two data streams by providing the control data into predetermined positions in the pilot data. The multiplexed data is then provided to a first input of multipliers **310** and **328**.

The second input of multiplier **310** is provided with a pseudonoise (PN) sequence of +1 and -1 values. The pseudonoise sequence provided to multipliers **310** and **312** is generated by multiplying the short PN sequence (PN_I) by the long code. The generation of short PN sequences and long code sequences is well known in the art and described in detail in the IS-95 standard. The second input of multiplier **328** is provided with a pseudonoise (PN) sequence of +1 and -1 values. The pseudo noise sequence provided to multipliers **318** and **328** is generated by multiplying the short PN sequence (PN_Q) by the long code.

The output of multiplier **310** is provided to a first input of multiplier **314**. The output of multiplier **318** is provided to delay element **320** which delays the input data by a time interval equal to half a chip. Delay element **320** provides the delayed signal to the subtracting input of subtractor **314**. The output of subtractor **314** is provided for transmission to baseband filters and pilot gain elements (not shown).

The output of multiplier **328** is provided to delay element **330** which delays the input data by half a chip cycle as described with respect to delay **320**. The output of delay element **330** is provided to a second summing input of summer **322**. The first input of summing element **322** is the output of multiplier **312**. The summed output from summer **322** is provided for transmission to baseband filters and pilot gain elements (not shown).

Traffic data to be transmitted on the supplemental channel, consisting of +1 and -1 values, is provided to a first input of multiplier **302**. The second input of multiplier **302** is provided with a repeating Walsh sequence (+1, -1). As described above the Walsh covering is to reduce the interference between channels of data transmitted from the remote station. The product data sequence from multiplier **302** is provided to gain element **304** which scales the amplitude to a value determined relative to the pilot/control channel amplification. The output of gain element **304** is provided to a first input of summer **316**. The output of summer **316** is provided to the inputs of multipliers **312** and **318** and processing continues as described above.

Traffic data to be transmitted on the fundamental channel, consisting of +1 and -1 values, is provided to a first input of multiplier **306**. The second input of multiplier **306** is provided with a repeating Walsh sequence (+1,+1,-1,-1). As described above the Walsh covering reduces the interference between channels of data transmitted from the remote station. The product data sequence from multiplier **306** is provided to gain element **308** which scales the amplitude to a value determined relative to the pilot/control

channel amplification. The output of gain element **308** is provided to a second input of summer **316**. The output of summer **316** is provided to the inputs of multipliers **312** and **318** and processing continues as described above.

Referring to Fig. 9, the embodiment of the present invention is illustrated to include the necessary filtering operations and illustrates an additional benefit attained by combining the pilot and control data. That is a reduction in the amount of necessary filtering circuitry. As described with respect to Fig. 8, the pilot data and control channel data are multiplexed together by multiplexer (MUX) **350**. The multiplexed data, consisting of +1 and -1 values, is provided to a first input of multipliers **352** and **354**. The second input of multiplier **352** is provided by multiplying the short PN code PN_I by the long code in multiplier **390**. The product from multiplier **352** is provided to finite impulse response (FIR) filter **356**. In the exemplary embodiment, FIR **356** is a 48 tap FIR filter, the design of which is well known in the art. The second input of multiplier **354** is provided by multiplying the short PN code PN_Q by the long code in multiplier **392**. The output of FIR **356** is provided to the summing input of subtractor **374**. The output of subtractor **374** is provided for transmission to upconverters and pilot gain elements (not shown).

The product from multiplier **354** is provided to finite impulse response (FIR) filter **358**. In the exemplary embodiment, FIR **358** is a 48 tap FIR filter, the design of which is well known in the art. It should be noted that by combining the pilot and power control data, two FIR filters have been eliminated since each channel requires two FIR filters. Elimination of two FIR filters reduces complexity, power consumption and chip area. The output of FIR **358** is provided to delay element **360** which delays the output by half a chip before providing the signal to a first summing input of summer **376**. The output of summer **376** is provided for transmission to upconverters and pilot gain elements (not shown).

The supplemental channel traffic data consisting of +1 and -1 values are provided to a first input of multiplier **362**. The second input to multiplier **362** is a repeating Walsh sequence (+1,-1) which as described previously reduce interference between the channels. The output of multiplier **362** is provided to a first input of multipliers **364** and **366**. The second input of multiplier **364** is the pseudonoise sequence provided from multiplier **392** and the second input to multiplier **366** is the pseudonoise sequence provided from multiplier **390**.

The output from multiplier **364** is provided to FIR/gain element **368** which filters the signal and amplifies the signal in accordance with a gain factor relative to unity gain of the pilot/control channel. The output of FIR/gain element **368** is provided to delay element **372**. Delay element **372** delays the signal by 1/2 a chip before providing the signal to a first subtracting input of subtracting element **374**. Processing of the output of subtractor **374** proceeds as described above.

The output from multiplier **366** is provided to FIR/gain element **370** which filters the signal and amplifies the signal in accordance with a gain factor relative to unity gain of the pilot/control channel. The output of FIR/gain element **370** is provided to a second input of summing element **376**. Processing of the output of subtractor **376** proceeds as described above.

The fundamental channel traffic data consisting of +1 and -1 values is provided to a first input of multiplier **388**. The second input to multiplier **388** is a repeating Walsh sequence (+1,+1,-1,-1) which as described previously reduces interference between the channels. The output of multiplier **388** is provided to a first input of multipliers **378** and **384**. The second input of multiplier **378** is the pseudonoise sequence provided from multiplier **392** and the second input to multiplier **384** is the pseudonoise sequence provided from multiplier **390**.

The output from multiplier **378** is provided to FIR/gain element **380** which filters the signal and amplifies the signal in accordance with a gain factor relative to unity gain of the pilot/control channel. The output of FIR/gain element **380** is provided to delay element **382**. Delay element **382** delays the signal by 1/2 a chip before providing the signal to a second subtracting input of subtracting element **374**. Processing of the output of subtractor **374** proceeds as described above.

The output from multiplier **384** is provided to FIR/gain element **386** which filters the signal and amplifies the signal in accordance with a gain factor relative to unity gain of the pilot/control channel. The output of FIR/gain element **386** is provided to a third input of summing element **376**. Processing of the output of subtractor **376** proceeds as described above.

Referring to Fig. 10, a receiver for processing the data wherein the control data is multiplexed with the pilot signal data is illustrated. The data is received by an antenna(not shown) and downconverted, filtered and sampled. The filtered data samples are provided to delay elements **400** and **402**. Delay element **400** and **402** delay the data by half of a chip cycle before providing the data to a first input of multipliers **404** and **406**. The second

input of multipliers **404** and **406** are provided with a pseudonoise sequence provided by multiplier **450**. Multiplier **450** generates the pseudonoise sequence by multiplying the short code PN_I by the long code as described previously.

The filtered samples are also provided directly (without delay) to a first input of multipliers **446** and **448**. The second input of multipliers **446** and **448** are provided with a pseudonoise sequence by multiplier **452**. Multiplier **452** generates the pseudonoise sequence by multiplying the short PN code (PN_Q) by the long code. The output from multiplier **404** is provided to a first input of summer **408**, and the output from multiplier **446** is provided to a second input of summer **408**. The output from multiplier **406** is provided to a summing input of subtractor **410**, and the output from multiplier **448** is provided to a subtracting input of subtractor **410**.

The output of summer **408** is provided to delay element **412** and pilot symbol selector **434**. Pilot symbol selector **434** gates out the control data from the pilot data, before providing the signal to pilot filter **436**. Pilot filter **436** filters the signal and provides the filtered pilot signal to multipliers **416** and **418**. Similarly, pilot symbol selector **438** gates out the control data from the pilot data, before providing the signal to pilot filter **440**. Pilot filter **440** filters the signal and provides the filtered pilot signal to multipliers **442** and **444**.

Delay **412** is used to synchronize the data through the two paths, before they are provided to multiplier **416**. That is to say that delay element **412** provides a delay that is equal to the processing delay of pilot symbol selector **434** and pilot filter **436** which is equal to the processing delay of pilot symbol selector **438** and pilot filter **440**. Similarly delay element **414** synchronizes the data provided to multipliers **418** and **442**.

The output of delay element **412** is provided to a first input of multipliers **416** and **444**. The second input to multiplier **416** is provided by the output of pilot filter **436**. The second input to multiplier **444** is provided by pilot filter **440**. The output of delay element **414** is provided to a first input to multipliers **418** and **442**. The second input to multiplier **418** is provided by the output of pilot filter **436**. The second input to multiplier **442** is provided by pilot filter **440**.

The output of multiplier **416** is provided to a first input of summer **420** and the second input to summer **420** is provided by the output of multiplier **442**. The sum from summer **420** is provided to control symbol selector **424** which separates the control data from the pilot channel data and

provides that information to a control processor not show which adjusts the base station transmission power in response thereto.

The output from multiplier **418** is provided to a summing input of subtractor **422**. The output from multiplier **444** is provided to a subtracting input of subtractor **422**. The output of subtractor **422** is provided to a first input of multiplier **426**. The second input of multiplier **426** is provided with the repeating Walsh sequence (+1,-1). the product from multiplier **426** is provided to summing element **428** which sums the input bits over the Walsh sequence period to provide the supplemental channel data. The output of subtractor **422** is provided to a first input of multiplier **430**. The second input of multiplier **430** is provided with the repeating Walsh sequence (+1,+1,-1,-1). the product from multiplier **430** is provided to summing element **432** which sums the input bits over the Walsh sequence period to provide the fundamental channel data.

Thus, a multi-channel, high rate, CDMA wireless communication system has been described. The description is provided to enable any person skilled in the art to make or use the present invention. The various modifications to these embodiments will be readily apparent to those skilled in the art, and the generic principles defined herein may be applied to other embodiments without the use of the inventive faculty. Thus, the present invention is not intended to be limited to the embodiments shown herein but is to be accorded the widest scope consistent with the principles and novel features disclosed herein.

WHAT I CLAIM IS:

CLAIMS

1. A subscriber unit or other transmitter for use in a wireless communication system, the subscriber unit comprising:

plural information sources of information data;

an encoder for encoding the information data;

plural control sources of control data; and

a modulator for modulating encoded information data with respective different modulating codes for transmission on a carrier signal, for combining the control data from the plural sources, and outputting the encoded information data and the combined control data for transmission.

2. A subscriber unit as claimed in claim 1, wherein the control data comprises power control data and pilot data.

3. A subscriber unit as claimed in claim 2, wherein the modulator is operable to multiplex the power control data with the pilot data.

4. A subscriber unit as claimed in claim 3, wherein the modulator is operable to combine the control data for continuous transmission.

5. A subscriber unit as claimed in claim 4, wherein the modulator is operable to modulate the information data for transmission from time to time.

6. A subscriber unit as claimed in any preceding claim, wherein the modulation codes are Walsh codes.

7. A subscriber unit as claimed in claim 6, wherein the Walsh code used to modulate the information data from a first one of the information sources is longer than the Walsh code used to modulate the information data from a second one of the information sources.

8. A subscriber unit as claimed in claim 7, wherein the Walsh code used to modulate the information data from the first one of the information sources comprises four chips, and the Walsh code used to

modulate the information data from the second one of the information sources comprises two chips.

9. A subscriber unit as claimed in any preceding claim, further comprising a combiner for combining the data from the modulator with each other and with a spreading code for transmission on a carrier signal.

10. A subscriber unit as claimed in claim 9, further comprising a transmitter circuit for transmitting the carrier signal carrying the spread, combined, modulated data.

11. A subscriber unit as claimed in any preceding claim, wherein the encoder is arranged to effect low code rate error correction and sequence repetition to the information data.

12. A base station or other receiver for use in a wireless communication system, the base station comprising:

a receiver for receiving a carrier signal and removing therefrom encoded information data from plural information sources modulated with respective different modulating codes and control data from plural control sources with the encoded control data being combined with each other;

a demodulator for demodulating the encoded information data and the control data from their respective different modulating codes; and

a decoder for decoding the encoded information data and demodulating the control data.

13. A method of transmission in a wireless communication system, the method comprising:

acquiring plural information data;

encoding the information data;

acquiring plural control data;

modulating encoded information data with respective different modulating codes for transmission on a carrier signal;

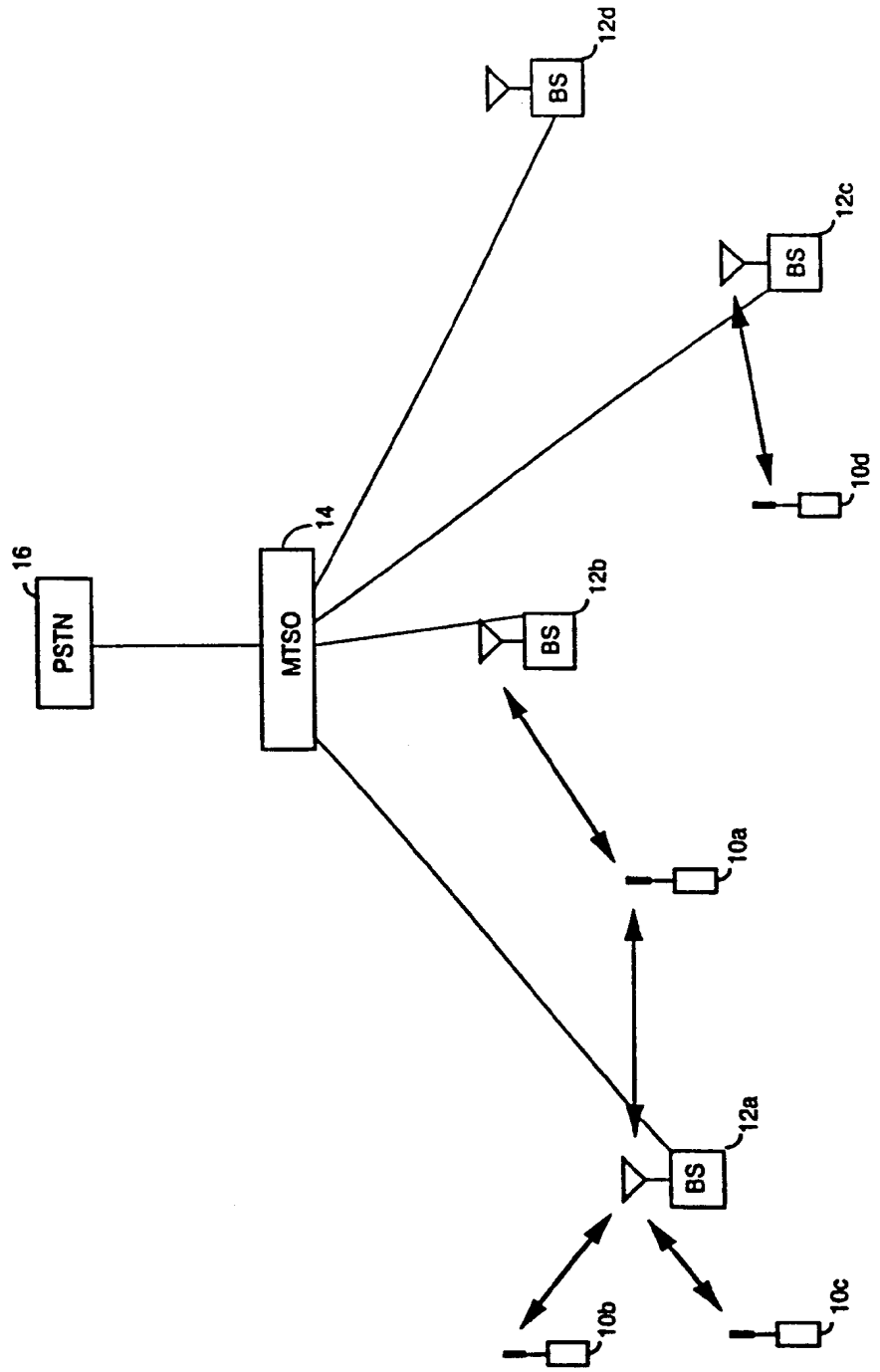
combining the control data from the plural sources; and

outputting the encoded information data and the combined control data for transmission.

14. A method for generating modulated data for transmission from a first subscriber unit in a set of subscriber units wherein said first subscriber unit transmits control data and pilot data to a base station in communication with the set of subscriber units comprising:

a) combining said control data with said pilot data; and

b) modulating said combined control data and pilot data onto in accordance with a single channel modulation format.



(PRIOR ART)

FIG.1

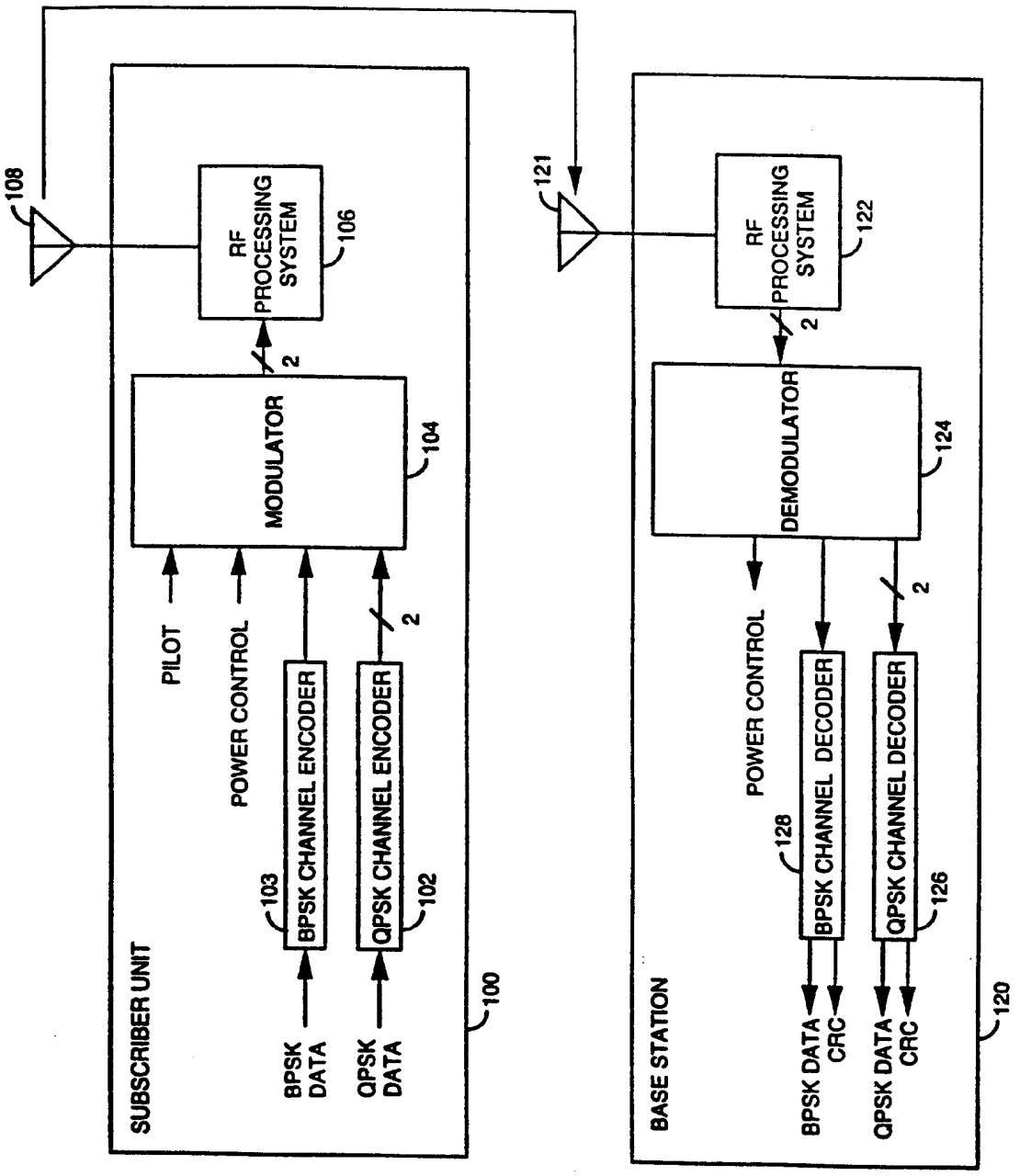

SUBSCRIBER UNIT
100
108
RF PROCESSING SYSTEM
106
MODULATOR
104
2
PILOT
POWER CONTROL
BPSK CHANNEL ENCODER
103
QPSK CHANNEL ENCODER
102
2
BPSK DATA
QPSK DATA
121
BASE STATION
120
RF PROCESSING SYSTEM
122
2
DEMODULATOR
124
POWER CONTROL
BPSK CHANNEL DECODER
128
QPSK CHANNEL DECODER
126
2
BPSK DATA
CRC
QPSK DATA
CRC

FIG. 2

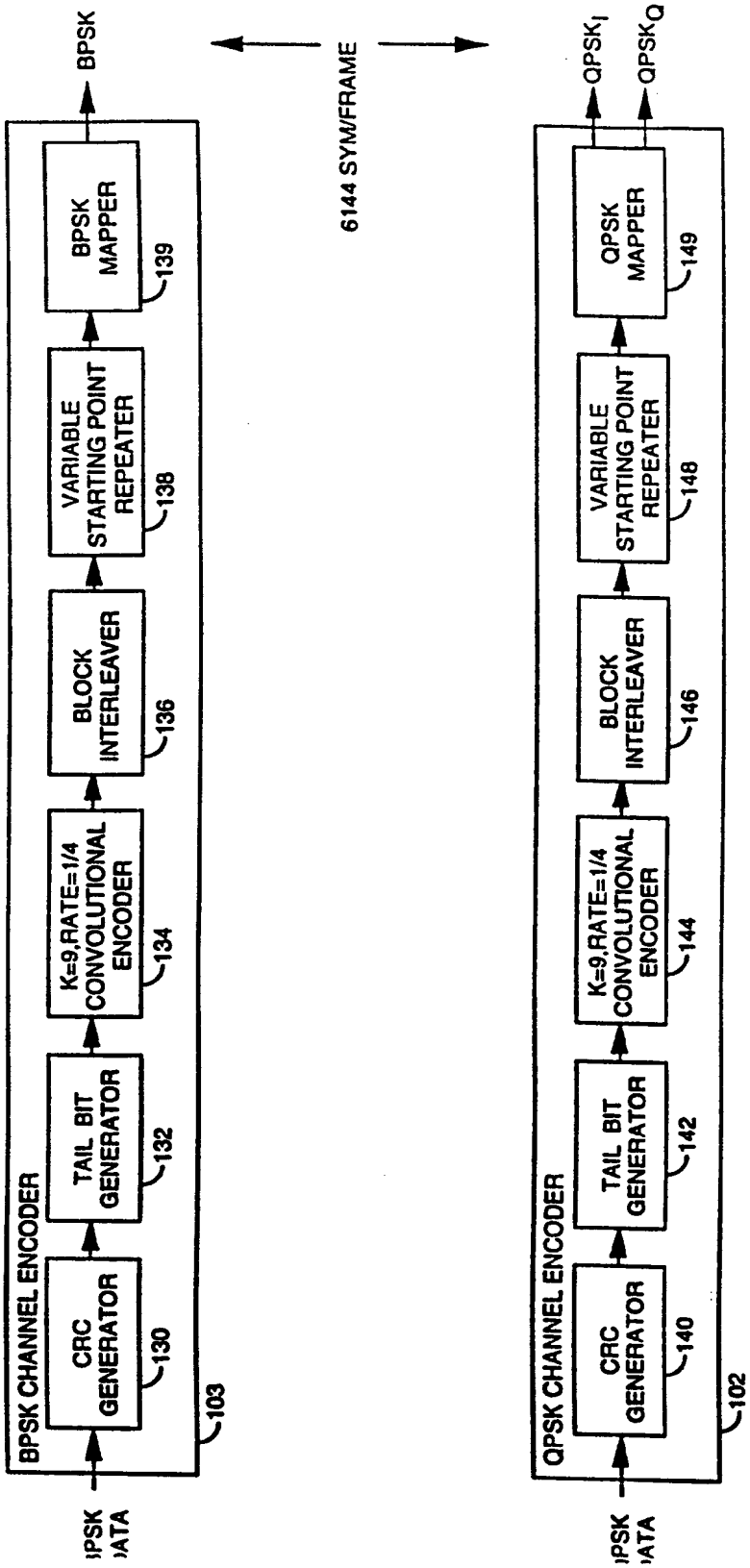

BPSK
BPSK MAPPER
139
VARIABLE STARTING POINT REPEATER
138
BLOCK INTERLEAVER
136
K=9,RATE=1/4 CONVOLUTIONAL ENCODER
134
TAIL BIT GENERATOR
132
CRC GENERATOR
130
BPSK CHANNEL ENCODER
103
6144 SYM/FRAME
QPSK$_I$
QPSK$_Q$
QPSK MAPPER
149
VARIABLE STARTING POINT REPEATER
148
BLOCK INTERLEAVER
146
K=9,RATE=1/4 CONVOLUTIONAL ENCODER
144
TAIL BIT GENERATOR
142
CRC GENERATOR
140
QPSK CHANNEL ENCODER
102

FIG. 3

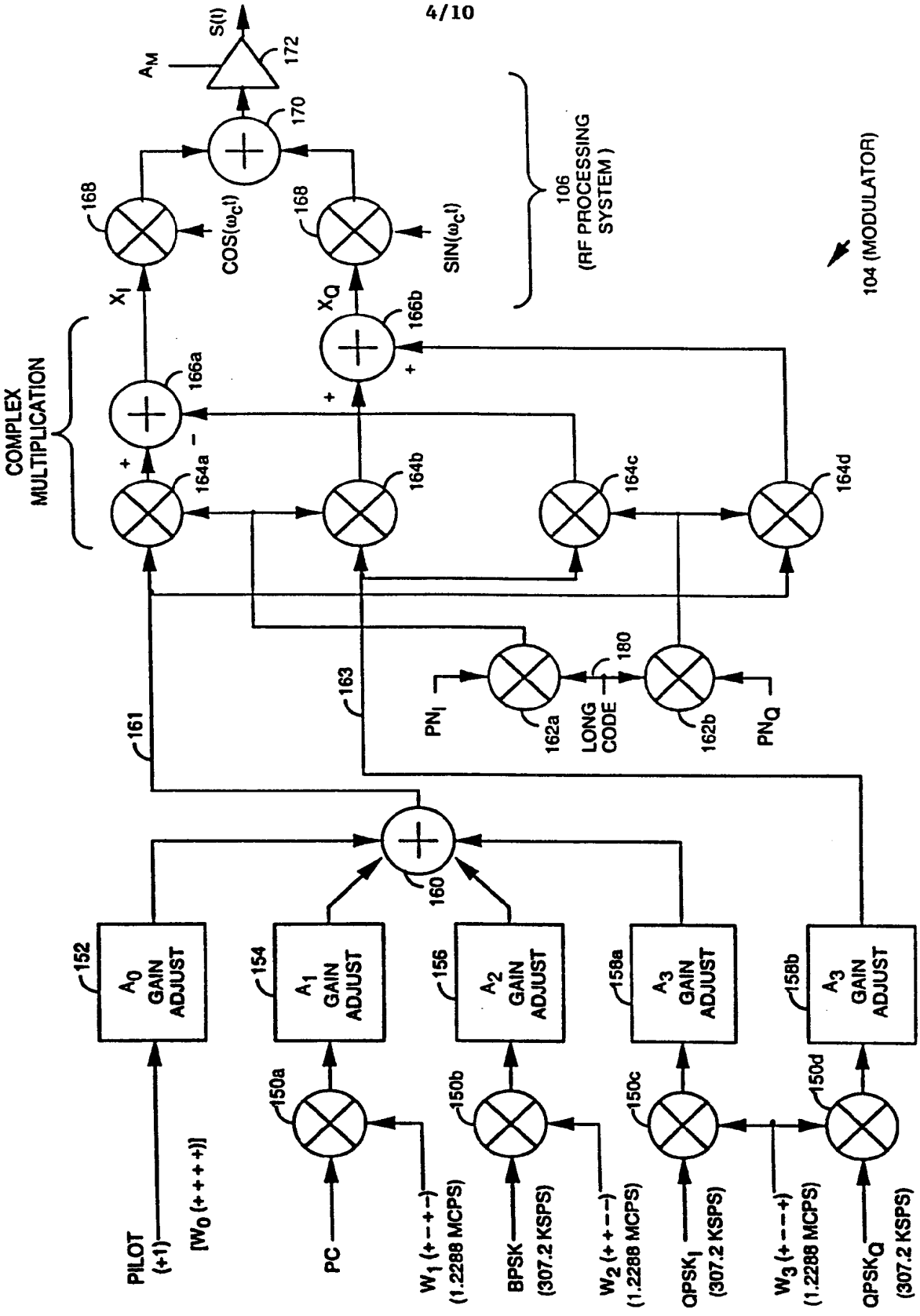

PILOT (+1)
[W0 (+ + + +)]
PC
W1 (+ – + –) (1.2288 MCPS)
BPSK (307.2 KSPS)
W2 (+ + – –) (1.2288 MCPS)
QPSKI (307.2 KSPS)
W3 (+ – – +) (1.2288 MCPS)
QPSKQ (307.2 KSPS)
A0 GAIN ADJUST
A1 GAIN ADJUST
A2 GAIN ADJUST
A3 GAIN ADJUST
A3 GAIN ADJUST
152
154
156
158a
158b
150a
150b
150c
150d
160
161
163
PNI
PNQ
LONG CODE
162a
162b
180
164a
164b
164c
164d
166a
166b
168
170
172
COMPLEX MULTIPLICATION
XI
XQ
COS(ωct)
SIN(ωct)
AM
S(t)
106 (RF PROCESSING SYSTEM)
104 (MODULATOR)

FIG. 4

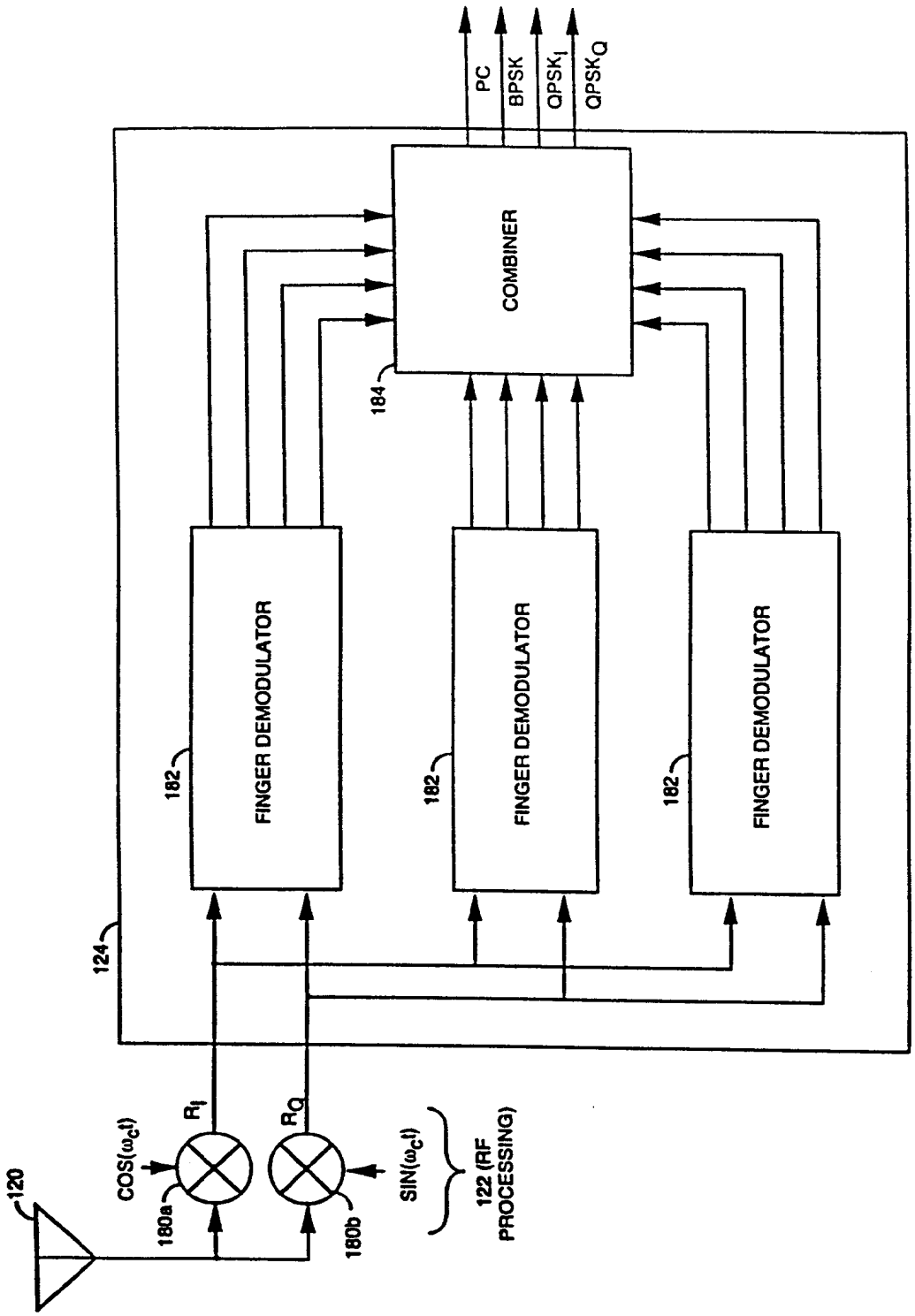

PC
BPSK
QPSK$_I$
QPSK$_Q$
COMBINER
184
FINGER DEMODULATOR
182
FINGER DEMODULATOR
182
FINGER DEMODULATOR
182
124
R_I
R_Q
COS(ω_ct)
SIN(ω_ct)
180a
180b
120
122 (RF PROCESSING)

FIG. 5

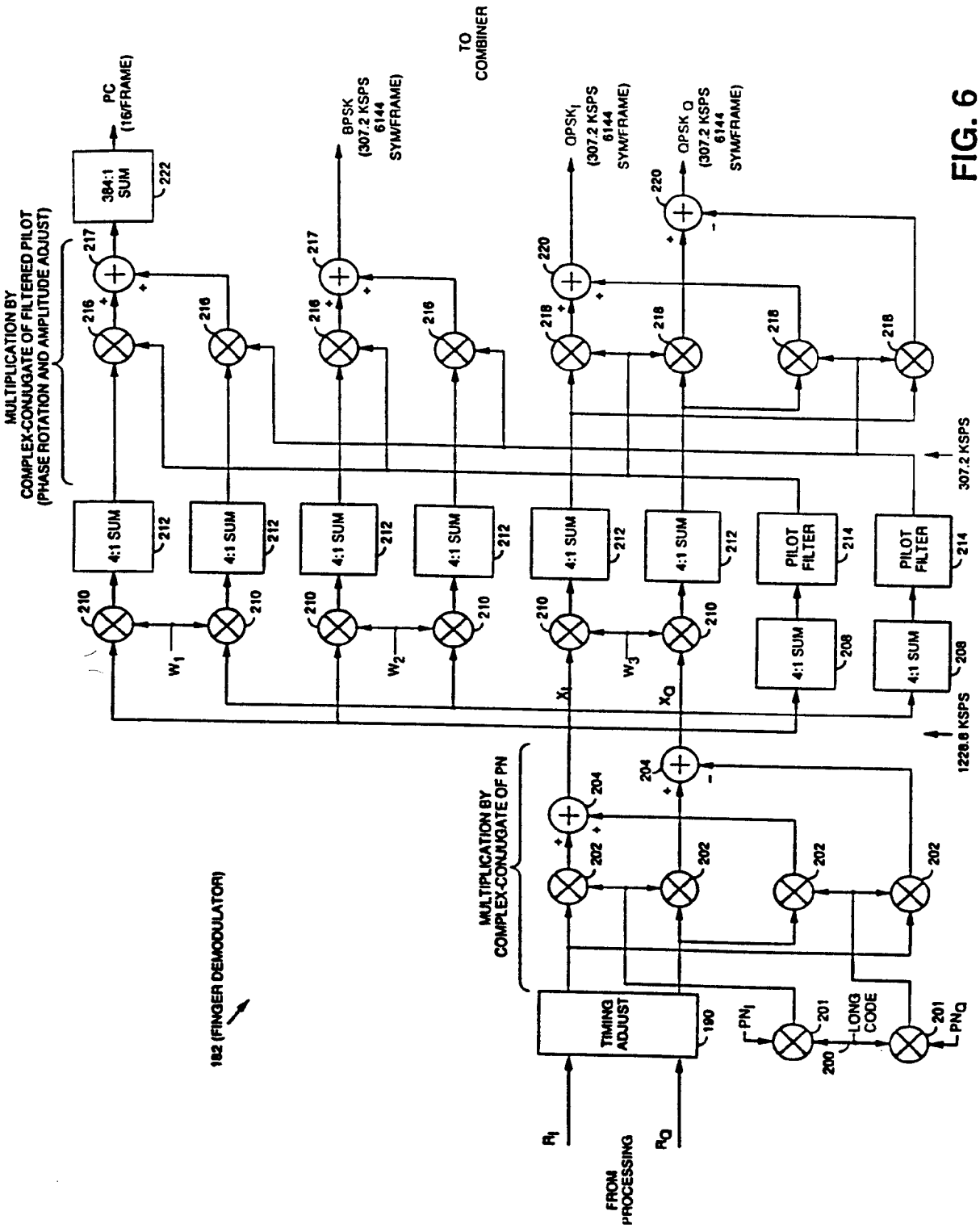

182 (FINGER DEMODULATOR)
FROM PROCESSING
R_I
R_Q
TIMING ADJUST
190
MULTIPLICATION BY COMPLEX-CONJUGATE OF PN
PN_I
PN_Q
LONG CODE
200
201
202
204
1228.8 KSPS
307.2 KSPS
4:1 SUM
208
PILOT FILTER
214
212
X_I
X_Q
W_1
W_2
W_3
210
MULTIPLICATION BY COMPLEX-CONJUGATE OF FILTERED PILOT (PHASE ROTATION AND AMPLITUDE ADJUST)
216
217
218
220
384:1 SUM
222
PC (16/FRAME)
BPSK (307.2 KSPS 6144 SYM/FRAME)
$QPSK_I$ (307.2 KSPS 6144 SYM/FRAME)
$QPSK_Q$ (307.2 KSPS 6144 SYM/FRAME)
TO COMBINER

FIG. 6

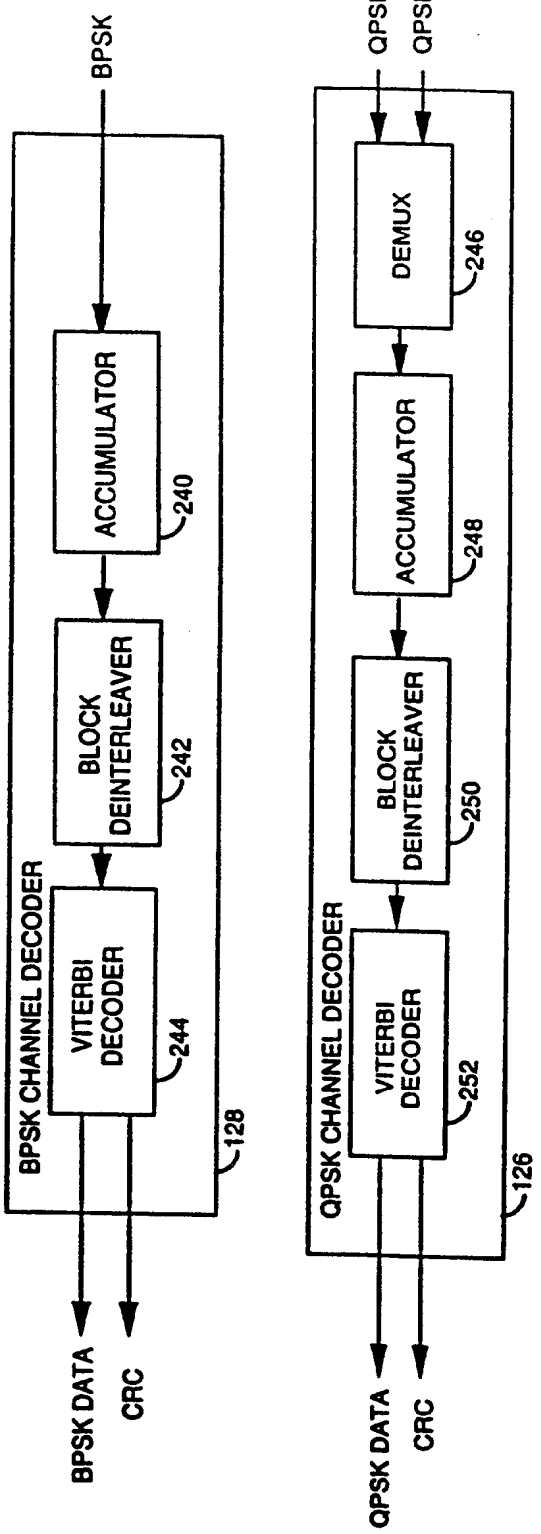

BPSK
ACCUMULATOR
240
BLOCK DEINTERLEAVER
242
VITERBI DECODER
244
BPSK CHANNEL DECODER
128
BPSK DATA
CRC
QPSK$_I$
QPSK$_Q$
DEMUX
246
ACCUMULATOR
248
BLOCK DEINTERLEAVER
250
VITERBI DECODER
252
QPSK CHANNEL DECODER
126
QPSK DATA
CRC

FIG. 7

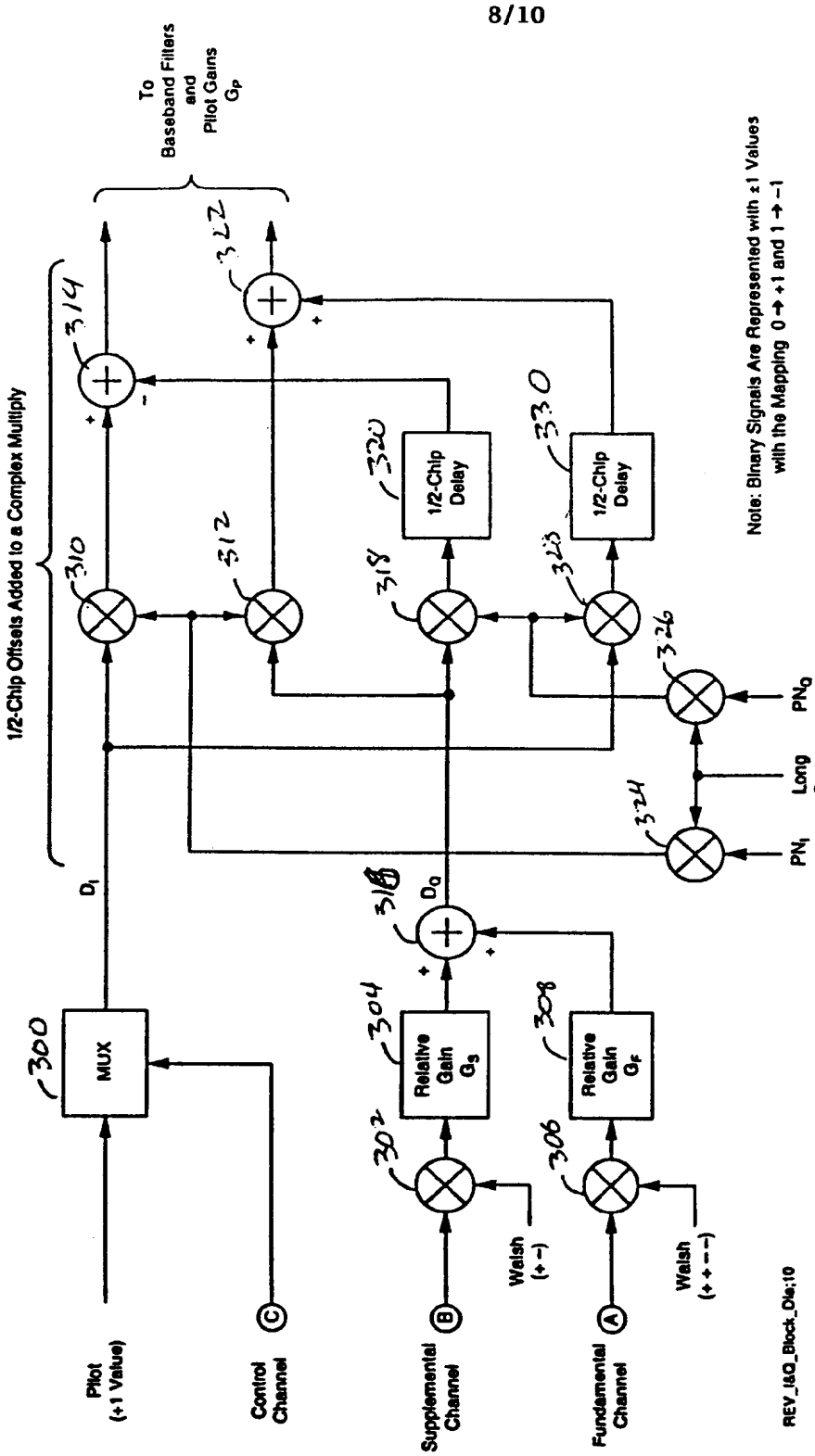


FIG. 8

3G Reverse Link

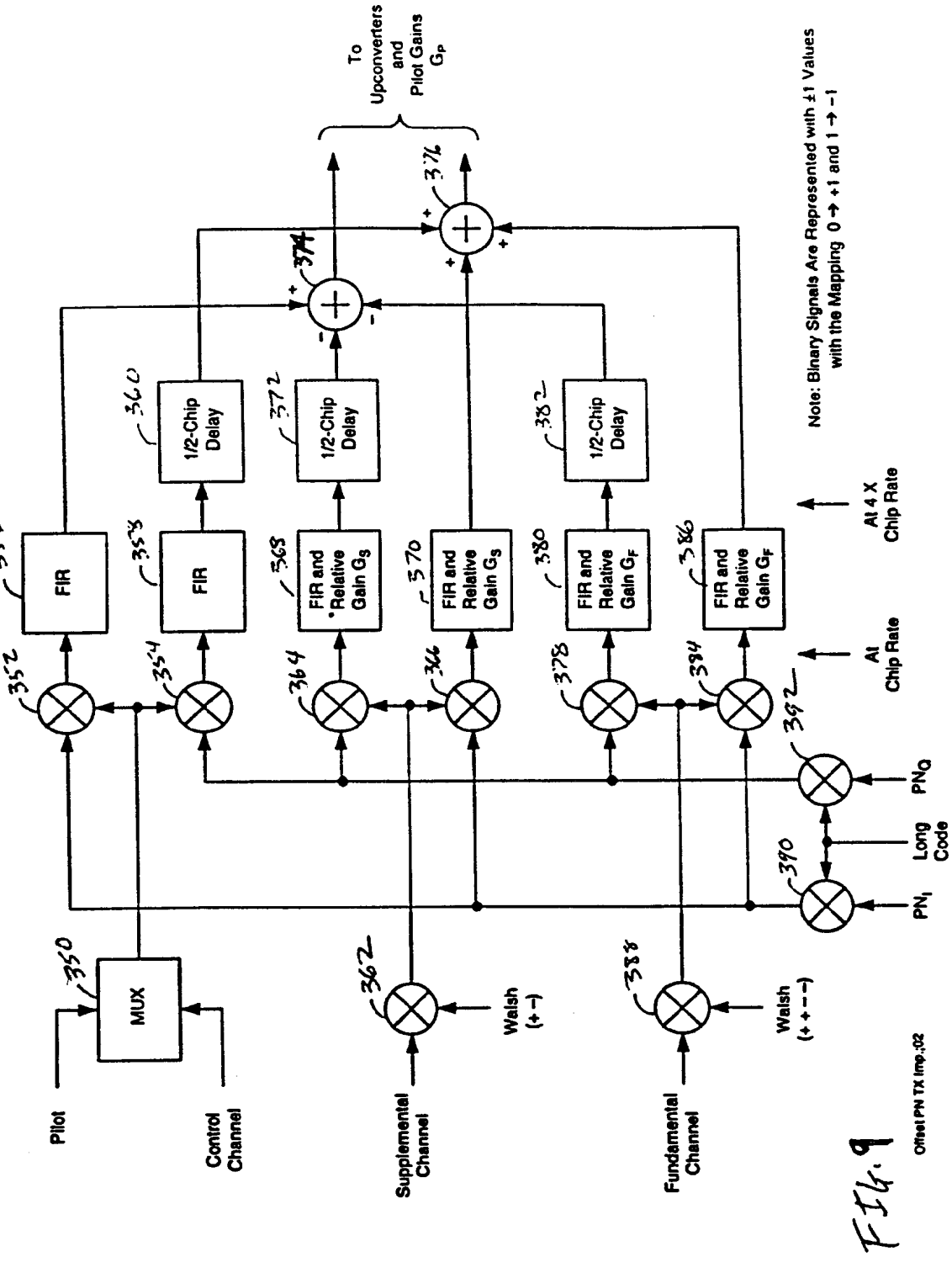


FIG. 9

3G Mobile Transmit Implementation Approach

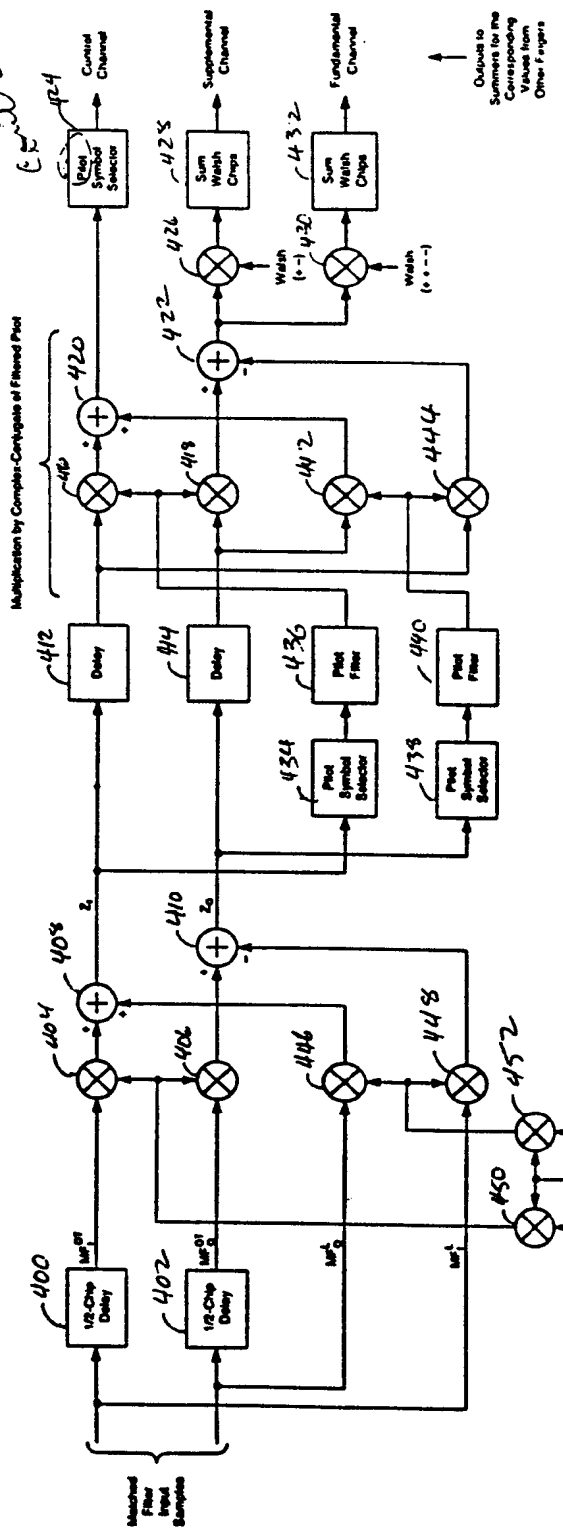


FIG. 10

3G Cell Receiver Implementation Approach per Finger